This document contains excerpts from the United Space Alliance (USA) Ground Operations Process Readiness Review Independent Assessment Report (title page shown below). Only those sections which relate to the PBMA element **Operations** are displayed.

The complete report is available through the PBMA web site, Program Profile tab.

Process Readiness Review

Space Shuttle Program

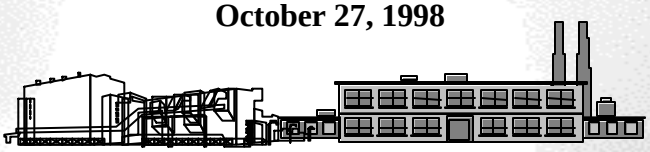
Space Flight Operations Contract (SFOC)

United Space Alliance

An Independent Assessment of SFOC/ USA-Ground Operations, NASA/SFOC Flight Operations, and NASA/KSC Safety & Mission Assurance

NASA Office of Safety & Mission Assurance

October 27, 1998



4.0 NASA/SFOC Flight Operations

The Flight Operations Review team of the Process Readiness Review (PRR) performed a high-level assessment of the readiness of both NASA and Space Flight Operations Contract/United Space Alliance (SFOC/USA) flight-critical processes to safely accommodate an increased annual flight rate at the current staffing levels and skill mix. This review was based on daily interaction with the Space Shuttle Program (SSP) and the SFOC/USA. In addressing the relative readiness of Flight Operations Processes, which are located at the Johnson Space Center (JSC), the Flight Operations Review Team had met with NASA Technical Management Representatives (TMRs) and SFOC/USA Associate Program Managers (APMs) for Orbiter Project, Systems and Cargo Integration Project, and Flight Operations Project. The review team made extensive use of presentation material from recent Program Manager's Reviews, Stratical (strategic/tactical management) Forums, and other SSP meetings in which OSMA staff regularly participates. The Review Team's discussions with TMRs and APMs took place on September 30 through October 2, 1998, and focused on acquiring answers to following questions:

- What are you doing, in the way of process improvements or enhancements, to prepare for a higher flight rate?
- What are you doing to maintain proficiency of the work force during the current lull in the Space Shuttle manifest and the projected lull between January and May 1999?
- How do you identify and account for critical skills in your organization and how do you prepare for attrition?
- What concerns, if any, do you have relative to the manifest, both in the near term and in the long term?

4.1 Orbiter Project Readiness Assessment

The Orbiter Project functions comprise four major areas: pre-launch and mission support; sustaining engineering, including upgrade development; manufacturing of the External Tank (ET) half of the 17-inch umbilical disconnect; and overall project management. In comparison to Ground Operations, the SFOC/USA Orbiter Project reduced its work force by approximately 14%, or just under 100 positions. All of the positions removed were at Boeing North American [now known as Boeing, Reuseable Space Systems (Boeing-RSS)] and either functioned as direct mission support or Orbiter sustaining engineering. There were no positions eliminated at the SFOC/USA project management level. The majority of the positions removed were found to be in the sustaining engineering area, which is not considered flight-rate sensitive. The staff removed from these positions is not completely out of the reach of the SSP; nearly all have been reassigned to other programs in Boeing-RSS and can be recalled to meet surge demands as necessary.

The Orbiter Project is aggressively working several initiatives that are needed if the current work force (minus projected, normal attrition) is to support an increase in annual flight rate in the future. The majority of the initiatives are focused on streamlining

critical operations processes in the sustaining engineering arena. This includes becoming more efficient in: production cycle time, especially in the ET umbilical manufacturing component; flight readiness engineering in support of USA and SSP reviews; and support to the on-going process flows at KSC. Metrics have been developed to baseline the effort spent in each of these areas in preparation to assess the efficiencies gained as the initiatives are implemented in the next year.

In each of the areas addressed in the Process Readiness Review, a common challenge was identified in the area of managing and maintaining critical skills needed to meet the overall SSP mission. The skills held by NASA and contractor work force are in high demand in other areas of the aerospace and information technology industries. SFOC/USA and Boeing-RSS are keenly aware that it is necessary to maintain the Orbiter corporate knowledge base so that Orbiter systems may be maintained and upgraded to support missions well into the next century. In the past, NASA and Boeing-RSS (formerly Rockwell) each retained subsystem managers and engineers for each major Orbiter subsystem, providing some measure of redundancy in the collective work force. With the transition of subsystem management responsibility to SFOC/USA and Boeing-RSS, NASA is reassigning the former subsystem managers and subsystem engineers. As this transition is completed, the final outcome will be a single-string subsystem manager capability in most of the SFOC/USA Orbiter functions.

Although this is not considered a problem today, SFOC/USA and Boeing-RSS have an ongoing challenge to maintain sufficient proficiency in the work force to overcome normal promotions and attrition in the management and engineering ranks. To counter this, SFOC/USA and Boeing-RSS have a plan in place to meet surge demands, as necessary. As stated above, most of the staff removed from directly supporting the Orbiter Project have been moved to other positions within Boeing-RSS and can be accessed as needed to support demand. A process is in place to temporarily rehire retirees for short periods of time to meet the need; in 1998, fifteen such retirees were brought back to assist in solving certain critical problems. A formal mentoring and job rotation process has been established for younger staff members to expose them to a greater variety of subsystems and to provide the opportunity to gain needed training from more experienced staff members. Additionally, SFOC/USA and Boeing-RSS have access to Boeing corporate resources to address critical problems when presented. Although a comprehensive database of Boeing corporate talent is on-line, the need to use this resource has yet to be tested.

The Flight Operations Review Team finds that the Orbiter Project Team, comprising NASA, SFOC/USA, and Boeing-RSS, are, with one exception, able to surge to a flight rate of eight flights per year. To gain the ability to sustain a higher annual flight rate, the Orbiter Project Team must continue to manage the critical skills necessary meet the projected demand and augment critical skills with Boeing corporate resources as needed. A concern identified by the Review Team relates to the instances when multiple anomalies are presented in a single subsystem, as has occurred many times in the past. The SFOC/USA and Boeing-RSS team believe that they will be capable of supporting analysis and resolution of multiple anomalies in a single subsystem by accessing Boeing

corporate resources; however, this capability has not yet been tested. In addition to the staffing challenges, the production of ET umbilicals must be made more efficient to meet a rate of eight flights per year and beyond. Current production levels are just keeping pace with demand. ETs are being shipped from the Michoud Assembly Facility without installed umbilicals; an undesirable situation.

4.2 Systems and Cargo Integration Project Readiness Assessment

The Systems and Cargo Integration Team is responsible for all engineering analyses that result in certifying the integrated Space Shuttle Vehicle for all flight and mission profiles. Integration processes are managed by SFOC/USA and performed by Boeing-RSS. The NASA Integration staff performs surveillance of SFOC/USA and Boeing-RSS processes through insight and oversight processes. The overall integration function is divided into key areas: Systems Integration, which addresses the assembled vehicle; Payload and Cargo Integration; SSP-to-ISS Integration; Verification Management; and Program Information Systems Integration. As in other areas, NASA has transitioned the management of Systems and Cargo Integration tasks to SFOC/USA; all transitions were completed by mid-1998.

Staff reductions made earlier this year in the SFOC/USA and Boeing-RSS Systems and Cargo Integration areas were minimal, numbering less than 25. At the current level, Systems and Cargo Integration staff can support up to eight flights per year. SFOC/USA and Boeing-RSS have several initiatives in work to reduce analysis cycle time to enhance their capability and support a higher flight rate. Key among these initiatives is a digital mock-up environment that enables analysts from all disciplines (thermal, structural, electrical, etc.) to conduct specific analyses in parallel. Other tools, including electronic development and delivery of reconfiguration drawings will also shorten the cycle time from flight to flight. The goal is to reduce the reconfiguration engineering time by 50% from the existing baseline in 1997 by the end of FY 2000, and indications are that the Integration Team is well on its way in meeting that goal.

The current Systems and Cargo Integration analysis processes are the constraining factors that define the flight rate capability. The flight analysis template now in place can be anywhere from 18 to 24 months in length, depending on the complexity of the payloads and mission profile. This is clearly demonstrated by the fact that even though the FY 1998 and FY 1999 flight rates were at five flights, the overall integration workload did not decrease due to the long lead time needed to develop the integrated certification for each flight. Recent manifest changes have caused certain analyses to be scrapped and re-performed due to changes in seasonal conditions that affect both launch and on-orbit loads. Changes in assignment of payloads to different vehicles also cause analyses to be re-performed due to the subtle differences among the Orbiters. Additionally, analysis of Shuttle upgrades and Orbiter enhancements that have been proposed or that are in work, require significant analysis to meet certification requirements. In summary, the Systems and Cargo Integration workload did not decrease commensurate with the flight rate and, in some cases, actually increased.

Critical skill retention has been an ongoing concern for SFOC/USA and Boeing-RSS in the Systems and Cargo Integration areas, as in other areas. The planned consolidation of the Boeing-RSS engineering function with the Boeing Expendable Launch Vehicle (ELV) engineering function at the Boeing-Huntington Beach facility is anticipated to provide greater workforce depth and stability. Tools and techniques used to perform required analyses for SSP are similar to those used for ELVs for payload integration and mission loads. For this reason, the combined Vehicle Integration work-force pool that will ultimately reside together at the Boeing-Huntington Beach facility can benefit all programs by sharing critical skills as needed to cover all demands on all programs. SFOC/USA has established a salary-grade update process based on an annual market survey to maintain salaries at competitive levels. The foundation for this process is a Critical Skills Retention Fund that is budgeted each year to provide incentive for the staff to stay with the program.

The Flight Operations Review Team finds that the NASA, SFOC/USA, and Boeing-RSS Systems and Cargo Integration Team have concerns for the future manifest, both near- and long-term. These concerns are based in part on the uncertainty of the ISS deployment schedule and the effect that continual manifest change will have in meeting their goals for improved cycle-time. In the long-term, there are concerns with the lack of post-ISS deployment missions thus far identified. These concerns, however, are considered by the Flight Operations Review Team to be beyond the control of the Systems and Cargo Integration Team.

The Flight Operations Review Team finds that the NASA, SFOC/USA, and Boeing-RSS Systems and Cargo Integration Team are actively planning for the future and flight rates up to and above ten flights per year. This is demonstrated by initiatives, both implemented and in work, to reduce certification analysis cycle time and to increase the efficient use of the combined work force. The ultimate consolidation of the Boeing-RSS SSP and ELV integration work force at the Boeing-Huntington Beach facility will enhance the capability to meet unplanned peaks and valleys in future manifests. The commitment by SFOC/USA to retaining critical skills is demonstrated by the budgeted Critical Skills Retention Fund and the continual management attention paid to this concern.

4.3 Flight Operations Project Readiness Assessment.

The Flight Operations Project Team comprises the NASA Mission Operations Directorate and SFOC/USA Flight Operations. Flight and mission operations continue to be a NASA-managed function; however, all other functions of Flight Operations are shared with, or directly tasked to the SFOC/USA Flight Operations staff. Overall, flight operations functions include: flight and mission operations; flight design, including payload operations; astronaut training and certification; flight controller training and certification; reconfiguration of flight software for each mission, including modifications for payload-unique functions; and customer mission support. The Flight Operations Project was not impacted by the SFOC/USA reduction in staff that was introduced in January 1998. Cost reductions needed were offset by adjustments in task content and

re-allocating uncommitted funds. In FY 1998, SFOC/USA Flight Operations has increased staff in preparation for the expected workload with ISS.

The Flight Operations Project Team currently has sufficient facilities and staff to support a flight rate of eight missions per year. An extensive overhaul of most Flight Operations Project processes, called "Reinventing Mission Operations" will provide the capability to reduce process cycle time and support higher annual flight rates in the future. Key enabling factors to reduce the overall Flight Operations process cycle time are:

- Ability to remove the payload operations portion of the vehicle software in order to reduce the need to re-configure software for similar missions. This will be most beneficial when flying repeated missions to ISS.
- Standardization of performance envelopes, thus reducing the need for extensive flight re-design for similar missions.
- Verification of flight software at incremental stages of development instead of a full-up verification at the end. This will reduce the need for repeated verification of the full flight software package when errors are found in specific areas of the software.
- Flight-similar training, providing the capability to reduce the number of mission-specific training modules currently required for each mission and enhance flexibility in the training schedule.
- Streamlining of real-time mission execution by providing common workstations and tools for all flight control staff.

As in the case of the Systems and Cargo Integration Project, the flight preparation template for flight plans and astronaut/flight controller training is approximately 12-18 months, thus preparation for future flights is already underway. The continuous rescheduling of the manifest has had an adverse impact on the Flight Operations training processes. This is due to the fact that certain certification requirements require certain training to be accomplished within a specific time prior to the mission. Moving missions further out in the calendar results in the need to repeat some training. Training process efficiency is adversely impacted by manifest changes; the effectiveness of the training process is not impacted. In addition to training, flight planning is adversely affected by moving mission payloads from one Orbiter to another. As this occurs, flight planning must also be assessed and adjusted as necessary.

In general, proficiency in many areas is not affected by flight rate. The areas that are flight-rate related (astronaut training instructors and flight controllers) maintain proficiency through support of the manifest and ongoing generic and flight-specific training. The reduced flight rate last year and the projected flight rate this year has provided the opportunity for additional training through simulations on actual mission control center consoles because the facility is not tied up with mission operations.

Of all of the projects reviewed, the Flight Operations Team finds that the Flight Operations Project has the best accounting of critical skills needed to perform their mission. This capability is not new. Critical skills identification and accounting has

been a long-standing process because the skills needed required specific training; these skills readily available in the aerospace industry. Critical skills staffing and certification is accurately tracked to maintain minimum requirements. A special compensation package is provided to those who maintain certification of their critical skills. Attrition is identified and planned for in staffing profiles and certification requirements.

The Flight Operations Review Team finds that the Flight Operations Project is planning for the future operations environment by reinventing the way they do business. Flight Operations has a clear understanding of the critical skills required to perform their mission and has the process in place to offset attrition of critical skills in the future. The Flight Operations Project continues to have concerns about the instability in the manifest, as do others. Continual changes and delays of missions in the manifest results in inefficiency by requiring time-sensitive training to be repeated. With changes planned in Flight Operations processes through the reinvention effort, the Flight Operations Project should be able to increase their annual flight-rate capability beyond their current seven-to-eight flights per year.

4.4 Summary

Overall, the three projects assessed in the Flight Operations Review portion of the Process Readiness Review can support a manifest requiring a rate of eight flights per year. Challenges continue in the area of critical skill retention; however, each project has a plan in place that is actively addressing this challenge. Initiatives identified by each project address the need to go to a higher annual flight rate.